Coláiste na Tríonóide, Baile Átha Cliath
Trinity College Dublin
Ollscoil Átha Cliath | The University of Dublin

FACULTY OF ENGINEERING, MATHEMATICS & SCIENCE

SCHOOL OF ENGINEERING

Electronic & Electrical Engineering

Engineering **Semester 1, 2018**

Senior Sophister

Annual Examinations

4C4 NEXT GENERATION NETWORKS

Thursday 13th Decmber 2018 **RDS-SIMMONS COURT** **17.00 – 19.00**

Dr Nicola Marchetti

Dr Marco Ruffini

Instructions to Candidates:

- **Answer FOUR questions from Part A, and EIGHT questions from Part B.**

Materials Permitted for this Examination:

- **Calculator**
- **Mathematical Tables**

PART A

Q.1

In a single server – finite buffer system, arrivals can be modelled as a Poisson process with rate 7.5 s^{-1} and the service times are exponentially distributed with mean 0.13 s.

(a) Give the Kendall's notation (motivate your choice).

[5 marks]

(b) Calculate the average number of customers in the system, assuming the maximum capacity of the system is 6 customers.

[3.5 marks]

(c) Calculate the blocking probability.

[2.5 marks]

Now assume we can serve up to 4 users simultaneously, no queuing is allowed, $\lambda = 2/3$ s^{-1} and the average service time is 4 s.

(d) Calculate the blocking probability.

[3.5 marks]

(e) How many servers are needed to keep the blocking probability below 0.1?

[3.5 marks]

Q.2

a) Indicate the LTE performance objectives.

[6 marks]

b) Describe the main aspects of scheduling in LTE networks.

[6 marks]

c) Indicate the LTE-Advanced goals.

[6 marks]

Q.3

a) We can define a cognitive radio as a "transceiver that is aware, adaptive, and capable of learning from experience".
Give at least four examples of what one means by 'aware' in this context, and at least four examples of what one means by 'adaptive'.

[11 marks]

b) Discuss briefly the motivation behind spectrum sharing. Discuss also the two main ways of achieving spectrum sharing, and give a graphical representation of both such ways in a time-frequency waterfall plot.

[7 marks]

Q.4

a) List at least 5 different types of copper-based access technologies (i.e., including both fully copper and hybrid copper-fibre), ordering them in ascending order of performance and highlighting their main features (bandwidth and capacity) and in which scenario are they typically used.

[9 marks]

b) Describe, drawing any necessary graph, how a Passive Optical Network schedules capacity both in the downstream and upstream directions. Then describe the different types of capacity assignment that can be delivered upstream.

[9 marks]

Q.5

a) Describe what are the advantages of introducing Reconfigurable Add Drop Multiplexers (ROADMs) into the network and what new challenges they bring compared to electronic cross-connects.

[6 marks]

b) What is the main purpose for using label-switched protocols such as Multi Protocol Label Switching (MPLS) in metro and core networks? Describe the concept of Forwarding Equivalence Class.

[6 marks]

c) Describe the different types of virtual LAN technologies available, emphasising their features, and their main advantage over traditional Ethernet switching.

[6 marks]

Q.6

a) An optical signal with bit rate of 10Gb/s runs over standard single mode fibre, with dispersion coefficient of 17ps/km/nm. The signal uses non-return-to-zero (NRZ) coding, which uses a bandwidth of 20 GHz. What is the maximum distance for the link if the maximum tolerable broadening of the optical pulses is equal to 50% of the bit time duration? (Assume the following conversion ratio: 100 GHz = 0.8 nm).

[9 marks]

b) You need to achieve a link distance of 1,000 km and you must compensate dispersion using dispersion compensating fibre (DCF) with coefficient of -150ps/km/nm. What length of DCF do you need if the signal operates at a bit rate of 40Gb/s? (Remember that the bandwidth of a signal increases proportionally with its bit rate). Assume the same relative ratios as the previous exercise for bandwidth conversion.

[9 marks]

PART B

For each question you pick, select only ONE answer out of the four available options.

Q.7

Which one among the following options **is not** a wireless channel impairment?

a) Path loss

b) Spatial diversity

c) Shadowing

d) Fading

[3.5 marks]

Q.8

Which one among the following functionalities **does not** belong to the OSI network layer?

a) Frame synchronization

b) Network-wide addressing

c) Inter-network handoff

d) Routing

[3.5 marks]

Q.9

Which one among the following options **is not** a "meter" in the cognitive radio sense?

a) Frequency of operation

b) Occupied bands

c) Signal strength

d) Neighbour list

[3.5 marks]

Q.10

Which one among the following requirements **is not** an "input" in queuing theory sense?

a) Number of users

b) Arrival characteristics

c) Waiting time

d) Service characteristics

[3.5 marks]

Q.11

In the Kendall's notation a/b/m/K, what is K indicating?

a) Number of servers

b) Service time distribution

c) Maximum number of customers allowed

d) Type of arrival process

[3.5 marks]

Q.12

Which one among the following statements **is false** when speaking about an ABM agent?

a) Does not need a central command to operate in large networks

b) Cannot operate in parallel with other ABM agents

c) It is anything that makes choices in a network

d) Can be adaptive

[3.5 marks]

Q.13

Which one among the following technologies is the **least** suitable for wireless local area networks?

a) LTE small cells

b) IEEE 802.11

c) GSM

d) 5G mm-wave

[3.5 marks]

Q.14

Which one among the following options is a multi-antenna diversity technique?

a) Transmit diversity

b) Time diversity

c) Frequency diversity

d) Channel coding

[3.5 marks]

Q.15

What is a main argument against net neutrality?

a) Operators should throttle capacity of applications indiscriminately

b) Different services, with different requirements should have different priority in order to work appropriately in the network

c) End user should not pay for broadband as this should be considered a commodity

d) If a service provider gains a position of monopoly it should be able to use it to fully control part of the network

[3.5 marks]

Q.16

Why did OpenFlow have bigger success than previous attempts to control and data plane separation?

a) Because it does not require centralisation of the network control

b) Because it uses active packets that can run code to change the behaviour of routers

c) Because it was the first to propose separation of control and data plane

d) Because it uses a protocol that is compatible with most of the existing hardware switches

[3.5 marks]

Q.17

Which of the following **does not** describe an optical cross connect:

a) A device that terminates optical signals and switch packets based on their headers.

b) A wavelength selective switch based on liquid crystals.

c) A device that can be used to build reconfigurable add drop multiplexers

d) A Micro Electro Mechanical System used to interconnect different fibres.

[3.5 marks]

Q.18

Which of the following **is not** an advantage of Passive Optical Networks over point-to-point fibre networks:

a) It has lower energy consumption

b) It requires the use of a smaller number of wavelengths

c) It reduces the number of termination ports on the central office

d) It uses a lower amount of optical fibre

[3.5 marks]

Q.19

Which of the following access network sharing paradigms creates issues with the vectoring technology:

a) Sub loop unbundling

b) Bitstream access

c) Virtual Unbundling Line Access

d) Next Generation Access Bitstream

[3.5 marks]

Q.20

Which of the following statements **is false** in regards of two-rate three color marker operations?

a) In color blind mode packets are processed independently of their previous color marking

b) In color aware mode, a packet marked as yellow can be re-marked as green if there is spare Committed Information Rate capacity

c) Packets bringing the total rate above the Peak Information Rate are dropped

d) Packets bringing the total rate above the Committed Information Rate are marked as yellow

[3.5 marks]

Q.21

For quality of service purposes, which of the following statements **is false**?

a) The use of large buffers can increase network delay and affect adversely voice over IP applications.

b) A shaper delays packets that bring the total rate above a given threshold

c) A policer discards packets that bring the total rate above a given threshold

d) Priority queuing provides fair scheduling of flows with different priority

[3.5 marks]

Q.22

Which of the following statements **is false** with respect to transport of cloud-RAN fronthaul links over an optical link?

a) It increases the required capacity significantly with respect to traditional backhaul

b) It poses strict latency constraints on the optical link

c) The use of compression techniques on I/Q samples lowers the signal quality

d) It does not allow sharing of baseband unit resources

[3.5 marks]